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$$\frac{dy}{dx}=-\frac{\sin 3\theta}{2\cos\theta+\cos 3\theta}=\frac{0}{0}, \text{ when } \theta=\frac{\pi}{3},\ \frac{2\pi}{3},\ \frac{4\pi}{3},\ \frac{5\pi}{3}.$$

$\therefore$ There are cusps at C, D, E, F. When $\theta=\frac{\pi}{6}$ and $\frac{5\pi}{6}$, $x=4a$, $y=0$, $dy/dx=\mp\frac{1}{\sqrt{3}}$; when $\theta=\frac{7\pi}{6}$ and $\frac{11\pi}{6}$, $x=-4a$, $y=0$, $dy/dx=\pm\frac{1}{\sqrt{3}}$.

$\therefore$ A and B are double points. The curve with the tangents at its double points is given in the figure. It is symmetrical to the axes, has four cusps and two double points.

$$(a),\ s=AMB=3a\Big[\theta+\sin 2\theta\Big]_{-\frac{\pi}{6}}^{\frac{\pi}{6}}=3a\left(\frac{\pi}{3}+\sqrt{3}\right)=a(\pi-3\sqrt{3}),$$

$$(b),\ s=AD=3a\Big[\theta+\sin 2\theta\Big]_{\frac{\pi}{6}}^{\frac{\pi}{3}}=\tfrac{1}{2}\pi a,$$

$$(c),\ s=DC=3a\Big[\theta+\sin 2\theta\Big]_{\frac{\pi}{3}}^{\frac{2\pi}{3}}=a(3\sqrt{3}-\pi).$$

Whole length of curve$=2AMB+4AD+2CD=2a(\pi+6\sqrt{3})$.

[The given curve is one of the involutes of a 4-cusped hypocycloid, which could be drawn surrounding the figure. The curve as given by the equations as first proposed is symmetrical to the axes, has two double points but no cusps. EDITOR.]

PROBLEMS.

47. Proposed by Professor J. SCHEFFER, A. M., Hagerstown, Maryland.

The floor of a vault forms a square, and all sections parallel to it are squares. The two vertical sections through the middle points of the opposite sides of the floor are equal semi-circles. Find the convex surface and the volume of the vault.

48. Proposed by G. B. M. ZERR, A. M., Ph. D., Professor of Mathematics and Applied Science, Texarkana College, Texarkana, Arkansas-Texas.

I have a circular section basin 12 inches in perpendicular height; the diameters are as follows: At base, 2 inches; one inch perpendicular height, 6 inches; two inches perpendicular height, 18 inches; three inches perpendicular height, 54 inches; and so on, the diameter being trebled for every inch in height. After a rain the water in the basin is six inches deep, what was the rainfall?